

## SPECIFICATION

Please amend the specification of the application as follows:

Following the title, please insert heading and paragraph [0001] as set forth below.

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a National Phase application claiming the benefit of International Application No. PCT/US2005/051409, filed March 29, 2005, which claims priority based on EP Application No. 04007529.3, filed March 29, 2004, the complete disclosure of which is incorporated herein by reference.

Please amend the following paragraphs in the specification as follows:

### TECHNICAL FIELD

[0002] The invention concerns a fastening element for affixing to a base as in the generic part of the first claim element is disclosed. The invention also concerns Additionally, a method for affixing a fastening element as in the generic part of the independent claims concerning the method is disclosed.

### [0003]PRIOR ARTBACKGROUND

[0003] Fastening elements used ~~To attach objects, especially in construction applications, such as, fastening elements, for example mounting bolts, of some kind are typically secured in the~~ into a base material by anchoring. ~~For example,~~ Generally, a hole is drilled in a concrete wall, a dowell is inserted into the hole, and the a mounting bolts are is screwed into threaded onto the dowell. Alternatively, ~~or the bolts are may be~~ embedded or glued into the hole. However, this is very costly and requires a number of steps. ~~With other base materials the~~ Additionally, affixing the fastening

~~element is in some cases even more difficult, since these for some materials, for instance steel, ceramic or glass, which are difficult to work.~~

[0004]     There are indeed Other securing systems that use employ thermoplastic adhesives, but these systems generally have low an insufficient load capacity, and do not provide a the bond is not permanent bond between the fastening element and the base material.

#### PRESENTATION OF INVENTION SUMMARY

[0005]     Various embodiments directed to a fastening element and a method for attaching the fastening element to a base material are disclosed herein. An illustrative embodiment of a fastening element comprises a mount and a reactive adhesive. The reactive adhesive generally hardens upon the application of an alternating field, thereby affixing the fastening element to a base material.

[0006]     An illustrative embodiment of a method for affixing a fastening element comprises pressing the fastening element against a base material with a fastening device, and applying an alternating field to the reactive adhesive through the device to harden the reactive adhesive, thereby affixing the fastening element to the base material.

~~The invention is based on the task of enabling a simple and reliable attachment with a fastening element for securing it to a base and a method for affixing a fastening element of the kind mentioned at the start.~~

~~In accordance with the invention, this is achieved through the traits of the first claim.~~

~~The core of the invention therefore is that the fastening element consists of a mounting support and a reactive adhesive.~~

~~The advantages of the invention can be seen, among other things, in the fact that a simple and reliable application is enabled through the fastening element in accordance with the invention.~~

~~Moreover, this application is possible on all substrates, since the reactive adhesive can easily be matched to said substrates. Moreover, the application of such fastening elements is much simpler and more reliable than with the traditional methods.~~

~~It is especially expedient when particles that react to alternating fields are arranged in the adhesive. In this way rapid hardening of the adhesive by means of alternating fields is possible.~~

~~Moreover, it is especially expedient when one-component adhesives with blocking are used. These adhesives enable simple application. The adhesives are extremely storage stable because of the blocking of resin and/or hardener, preferably resin and hardener, and they are not susceptible to moisture. Rapid hardening can be achieved by radiation-induced heating of the adhesive without heating the surroundings. Such adhesives, moreover, have good mechanical strength that can be set in a wide range. These advantages also arise with two-component adhesives, although they must be kept separately and must be able to be dispensed easily.~~

~~Other advantageous embodiments of the invention result from the dependent claims.~~

#### BRIEF DESCRIPTION OF THE DRAWINGS

~~Embodiment examples of the invention are explained in more detail below by means of drawings. Like elements in the different figures are indicated with the same reference numbers.~~

~~Here:~~

[0007] Figure 1 shows a schematic representation of the fastening element in accordance with the invention~~an embodiment~~;

[0008] Figure 2 shows a schematic representation of a fastening element with an auxiliary adhesive;

[0009] Figure 3 shows a schematic representation of a fastening element with rupturing elements;

[0010] Figure 4 shows a schematic representation of the adhesive from Figure 3 with packaged components;

[0011] Figure 5 shows another schematic representation of the adhesive from Figure 3 with packaged components;

[0012] Figure 6 shows a schematic representation of a fastening element with an additional primer layer.

#### METHODS OF EMBODIMENT OF INVENTION DETAILED DESCRIPTION

**[0013]** Reference in the specification to “one embodiment” or “an embodiment” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase “in one embodiment” in various places in the specification are not necessarily all referring to the same embodiment.

~~In this invention a storage-stable reactive adhesive system is used to secure a fastening element to a base element. In accordance with~~Turning now to Figure 1, ~~such a fastening element 1 consists is illustrated which comprises of a mounting support 3 and a reactive adhesive 4. Fastening element 1 may be applied to base element 5 with a fastening device 2, which may be generally matched in shape and/or size to fastening element 1. The fastening element 1 is secured to base element 5 by means of a fastening device. It goes without saying that the~~The fastening element can have any shape, and can ~~and must~~ be matched to the elements that are to be fastened onto it in each case.

**[0014]** ~~Many different systems compounds can be used for the reactive adhesive. However~~Preferably, an important point of this invention is that the fastening element can be affixed to the base element as rapidly as possible, i.e., the application of the fastening element takes as little time as possible. ~~For this, on the one hand, the~~The reactive adhesive can be designed so that rapid hardening takes place, ~~and on the other hand~~Alternatively, or in addition to the rapid hardening of the reactive adhesive, the fastening element can be held on the base element with another adhesive 6 (Figure 2) ~~until while the reactive adhesive has produced sufficient adhesive effect is hardening.~~

**[0015]** ~~Reactive A variety of embodiments of adhesives reactive adhesive 4 that can be used for the invention are indicated below~~utilized. Of course, ~~other~~Other adhesives can also be used if they have the required properties.

#### EXAMPLES OF REACTIVE ADHESIVES: ONE COMPONENT SYSTEMS

**[0016]** In one embodiment, a one-component reactive adhesive that can may be used. The one-component reactive adhesive is preferably for the invention is a storage-stable polymer composition that is characterized by the fact that it containsgenerally comprises at least one resin A that enters into polyreactions, at least one, ~~especially a blocked,~~ hardener B, at least one type of nanoparticle C with either ferromagnetic, ferrimagnetic, superparamagnetic or piezoelectric properties, at least one

additive D, and optionally other components, ~~where preferably at least one of the~~ At least one of components A or B ~~is~~ may be advantageously provided in blocked form, to prevent reaction between resin A and hardener B prior to application of fastening element 1. Upon application of electrical, magnetic and/or electromagnetic alternating fields the nanoparticles C are stimulated, heating the particles and the reactive adhesives ~~so that their environment is greatly heated through the transfer of energy~~. As a ~~consequence~~ result of this local temperature elevation the components A and/or B become activated through deblocking or capsule rupture, so that the reactive adhesive rapidly hardens.

[0017] ~~In a first embodiment~~ In a first general example, the one-component reactive adhesive is a polyurethane composition. It ~~is characterized by the fact that it contains~~ generally comprises, as resin A that enters into polyreactions, a polyurethane polymer that contains a free or blocked isocyanate group. The term "polymer" in this document means on the one hand a collective of chemical uniform macromolecules that, however, differ in degree of polymerization, molecular weight and chain length, which was prepared by a polyreaction (polymerization, polyaddition, polycondensation). On the other hand, the term "polymer" in this document also includes derivatives of such a collective of macromolecules from polyreactions, therefore compounds that were obtained by reactions, for example additions or substitutions, of functional group to the said macromolecules and which can be chemically uniform or chemically heterogeneous.

[0018] The term "polymer composition" as described herein may generally mean a homogeneous or heterogeneous mixture of substances that comprises one or more polymers or contains polymers in a considerable amount.

[0019] The term "polyurethane" ~~in this document~~ as described herein ~~means~~ refers to all polymers that are prepared by the diisocyanate polyaddition process. This also ~~included~~ includes polymers that are nearly or entirely free of urethane group, for instance polyether polyurethanes, polyester polyurethane, polyether polyureas, polyureas, polyester polyureas, polyisocyanurates, polycarbodiimides, etc.

**[0020]** The prefix "poly" in the names of substances like "polyol", "polyisocyanate" or "polyamine" as described herein ~~in this document~~ indicates that the relevant substance formally contains more than one of the functional groups that occur in its name per molecule.

**[0021]** The isocyanate group-containing polyurethane polymer is prepared by the reaction of at least polyol with at least one polyisocyanate. This reaction can take place by reacting the polyol and the polyisocyanate with conventional methods, for example at temperature of 50°C to 100°C, optionally with the co-use of suitable catalysts, where the polyisocyanate is dispensed so that its isocyanate groups are present in stoichiometric excess with respect to the hydroxyl group of the polyol. The excess of polyisocyanate is chosen so that in the resulting polyurethane polymer, after the reaction of all of the hydroxyl groups of the polyol, there remains, for example, a certain content of free isocyanate group of 0.1-15 wt%, preferably 0.5-5 wt%, with respect to the entire polyurethane polymer. Optionally, the polyurethane polymer can be prepared with the co-use of plasticizers, where the plasticizers that are used do not contain group that have reactivity for isocyanates.

**[0022]** For example, the following commercial polyols or any mixtures thereof can be used as polyols for the preparation of such an isocyanate group-containing polyurethane polymer:

- Polyoxyalkylene polyols, also called polyether polyols, which are polymerization producers of ethylene oxide, 1,2-propylene oxide, 1,2- or 2,3-butylene oxide, tetrahydrofuran, or mixtures thereof, possible polymerized with the help of a starter molecule having two or more active hydrogen atoms such as water, ammonium or compounds with several OH or NH group such as 1,2-ethanediol, 1,2- and 1,3-propanediol, neopentyl glycol, diethylene glycol, triethylene glycol, the isomeric dipropylene glycols and tripropylene glycols, the isomeric butanediols, pentanediols, hexanediols, heptanediols, octanediols, nonanediols, decanediols, undecanediols, 1,3- and 1,4-cyclohexanedimethanol, bisphenol A, hydrogenated bisphenol A, 1,1,1-trimethylolethane, 1,1,1-trimethylolpropane, glycerol, aniline, and mixture of the said compounds. Both polyoxyalkylene polyols that have a low degree of unsaturation (measured by ASTM D-2849-69 and given in milliequivalents of unsaturation per gram of polyol (meq/g)), which were prepared for example with the help of the so called double metal cyanide complex catalysts (DMC Catalysts), as well as

polyoxyalkylene polyols with a higher degree of unsaturation, which are prepared, for example, with the help of anionic catalysts like NaOH, KOH or alkali alcoholates, can be used. Polyoxyalkylenediols or polyoxyalkylenetriols especially polyoxypropylenediols or polyoxypropylenetriols, are especially suitable.

[0023] Particularly suitable are polyoxyalkylenediols or polyoxyalkylenetriols with a degree of unsaturation lower than 0.02 meq/g and a molecular weight in the range of 1000 to 30000 g/mol, and polyoxypropylenediols and -triols with molecular weight from 400 to 8000 g/mol. "Molecular weight" or "mol weight" are understood in this document to always mean the weight average molecular weight  $M_n$ .

[0024] Likewise especially suitable are the so called "EO-end capped" (ethylene oxide end capped) polyoxypropylenediols or -triols. The latter are particular polyoxypropylene polyoxyethylene polyols, which are obtained, for example, by alkoxyating polyoxypropylene polyols with ethylene oxide after the end of the polypropoxylation and which because that have primary hydroxyl group.

- Styrene-acrylonitrile graft polyether polyols, such as are sold by Bayer under the name Lupranol.
- Polyester polyols, prepared, for example, for di- or trihydric alcohols such as 1,2-ethanediol, diethylene glycol, 1,2-propanediol, dipropylene glycol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, neopentyl glycol, glycerol, 1,1,1-trimethylolpropane or mixtures of the said alcohols with organic dicarboxylic acids or their anhydrides or esters such as succinic acid, glutaric acid, adipic acid, suberic acid, sebacic acid, dodecanedicarboxylic acid, maleic acid, fumaric acid, phthalic acid, isophthalic acid, terephthalic acid and hexahydrophthalic acid or mixtures of said acids, and polyester polyols of lactones such as  $\epsilon$ -caprolacton.
- Polycarbonate polyols, as are accessible by the reaction of, for example, the alcohols indicated above (used to synthesize the polyester polyols) with dialkyl carbonates, diaryl carbonates or phosgene.
- Polyacrylate and polymethacrylate polyols.
- Polyhydroxy-terminated polybutadiene polyols such those that are prepared by polymerization of 1,3-butadiene and allyl alcohol.

- Polyhydroxy terminated acrylonitrile/polybutadiene copolymers, as can be prepared, for example, from epoxides or amino alcohols and carboxyl-terminated acrylonitrile/polybutadiene -copolymers (commercially available under the name Hycar® CTBN from Hanse Chemie). These polyols have an average molecular weight of 250 to 30,000 g/mol, especially 1000 to 30,000 g/mol, and an average OH functionality in the range of 1.6 to 3.

[0025] In addition to these polyols, low-molecular di- or polyhydric alcohols such as 1,2-ethanediol, 1,2- and 1,3-propanediol, neopentyl glycol, diethylene glycol, triethylene glycol, the isomeric dipropylene glycols and tripropylene glycols, the isomeric butanediols, pentanediols, hexanediols, heptanediols, octanediols, nonanediols, decanediols, undecanediols, 1,3- and 1,4-cyclohexanedimethanol, hydrogenated bisphenol A, dimer fatty alcohols, 1,1,1-trimethylolethane, 1,1,1-trimethylolpropane, glycerol, pentaerythritol, sugar alcohols and other more highly hydric alcohols, low-molecular alkoxylation products of the said di- and polyhydric alcohols and mixtures of the said alcohols can also be used in the preparation of the polyurethane polymer.

[0026] Commercial polyisocyanates may be ~~are~~ used as polyisocyanates for the preparation of an isocyanate group-containing polyurethane polymer. The following polyisocyanates, the best known in polyurethane chemistry, may be mentioned as examples: 2,4- and 2,6-toluene diisocyanate (TDI) and any mixtures of these isomers, 4,4'-diphenylmethane diisocyanate (MDI), the diphenylmethane diisocyanate positional isomers, 1,3- and 1,4-phenylene diisocyanate, 2,3,5,6-tetramethyl-1,4-diisocyanatobenzene, 1,6-hexamethylenediisocyanate (HDI), 2-methylpentamethylene 1,6-diisocyanate, 2,2,4- and 2,4,4-trimethyl-1,6-hexamethylene diisocyanate (TMDI), 1,12-dodecamethylene diisocyanate, cyclohexane-1,3- and 1,4-diisocyanate any mixtures of these isomers, 1-isocyanato-3,3,5-trimethyl-5-isocyanatomethylcyclohexane (= isophorone diisocyanate or IPDI), perhydro-2,4'- and -4,4'-diphenylmethane diisocyanate (HMDI), 1,4-diisocyanato-2,2,6-trimethylcyclohexane (TMCDI), m- and p-xylylene diisocyanate (XDI), 1,3- and 1,4-tetramethylxylylene diisocyanate (TMXDI), 1,3- and 1,4-bis(isocyanatomethyl)cyclohexane, and oligomers and polymers of the said isocyanates, and any



mixtures of the said isocyanates. MDI, TDI, HDI and IPDI and their mixtures are especially generally preferred. MDI and TDI and their mixtures are ~~most~~ generally more preferred.

[0027] In one ~~a preferred~~ embodiment, the isocyanate group-containing polyurethane polymer is blocked. The blocking takes place by reacting the isocyanate group-containing polyurethane polymer with a blocking agent. The reaction preferably takes place by mixing the isocyanate group-containing polyurethane polymer with the blocking agent in a stoichiometric ratio with respect to the content of isocyanate group and causing it to react at a temperature of 20 to 120°C until almost no free isocyanate groups can be detected. If desired, a catalyst can also be used, for example a tin or bismuth compound.

[0028] Examples of suitable blocking agents are phenols like phenol, cresol, xlenol, p-ethylphenol, o-isopropylphenol, p-tert-butylphenol, p-tert-octylphenol, nonylphenol, dodecylphenol, thymol, p-naphthol, p-nitrophenol, p-chlorophenol, 2-pyridinol; phenol group-containing hydrocarbon resins like cumaron-indene resins, petroleum resins, terpene resins; alcohols like methanol, ethanol, propanol, isopropanol, butanol, 2-butanol, isobutanol, ethylene glycol, ethylene glycol methyl ether (Methyl Cellosolve®), ethylene glycol butyl ether (Butyl Cellosolve®), ethylene glycol phenyl ether (Phenyl Cellosolve®) diethylene glycol monomethyl ether (Methyl Carbitol®), diethylene glycol monobutyl ether (Butyl Carbitol®), benzyl alcohol, furfuryl alcohol, cyclohexanol; 1,3-dicarbonyl compounds like dimethyl malonate, diethyl malonate, diethyl methylmalonate, ethyl acetoacetate, 2,4-pentanedione; mercaptans like butylmercaptans, hexylmercaptans, dodecylmercaptans, thiophenol, 2-mercaptopyridine; carboxylic amides like acetamide, acetanilide, acetaniside, benzamide; carboxylic imides like succinimide, maleimide; amines like diisopropylamine, dicyclohexylamine, N-tert-butyl-N-benzylamine, 2,6-dimethyl piperidine, diphenylamine, phenylnaphthylamine, aniline, 9H-carbazole; nitrogen heterocycles like imidazole, 2-methylimidazole, 2-ethylimidazole, benzimidazole, pyrazole, 3,5-dimethylpyrazole, 1,2,4-triazole, benzotriazole; ureas like urea, thiourea, imidazolidin-2-one; aldoximes like formaldoxime, acetaldoxime; ketoximes like methyl ethyl ketoxime, methyl isopropyl ketoxime, methyl isobutyl ketoxime, methyl amyl ketoxime, diisopropyl ketoxime, cyclohexanoxime; lactams like  $\epsilon$ -caprolactam,  $\delta$ -valerolactam,  $\gamma$ -butyrolactam,  $\beta$ -propiolactam; imines like ethyleneimine; N-hydroxysuccinimide; 2-benzoxazolone, 1,3-benzoxazin-2,4-dione;

bisulfites like sodium bisulfite, potassium bisulfite; and other blocking agents, as are mentioned in the two review articles by D. A. Wicks and Z. W. Wicks, Jr., "Blocked Isocyanates," published in Organic Coatings 36 (1999), 148-172 and Progress in Organic Coatings 41 (2001), 1-83/ Phenols, hydrocarbon resins, alcohols, oximes, nitrogen heterocycles, 1,3-dicarbonyl compounds, amines and lactams are preferred as blocking agents. Methyl ethyl ketoxime, methyl isobutyl ketoxime, pyrazole, 3,5-dimethyl pyrazole, 1,2,4-triazole, benzotriazole, dimethyl malonate, diethyl malonate diisopropylamine, dicyclohexylamine, N-tert-butyl-N-benzylamine and  $\epsilon$ -caprolactam are especially preferred.

**[0029]** As for hardener B<sub>1</sub> the polyurethane composition ~~contains~~ may contain a hardener that contains group that are reactive ~~towards~~ with isocyanates and that are in blocked form, where the blocking can be of chemical or physical nature. Examples of suitable chemically blocked hardeners are polyamines bound to metals via a complexing compound, especially complex compounds of methylenedianiline (MDA) and sodium chloride. Such complex compounds are usually described with the empirical formula (MDA)<sub>3</sub>·NaCl. One suitable type is available as a dispersion in diethylhexyl phthalate under the trade name Caytur® 21 from Crompton Chemical. The complex breaks down upon heating to 80-160°C at a rate that increases with higher temperature, through which the methylenedianiline is released as the active hardener. Examples of physically blocked hardeners are microencapsulated hardeners. Di- or polyhydric alcohols like 1,2-ethanediol, 1,2- and 1,3-propanediol, neopentyl glycol, diethylene glycol, triethylene glycol, the isomeric dipropylene glycols and tripropylene glycols, the isomeric butanediols, pentanediols, hexanediols, heptanediols, octanediols, nonanediols, decanediols, undecanediols, 1,3- and 1,4-cyclohexanedimethanol, hydrogenated bisphenol A, dimer fatty alcohols, 1,1,1-trimethylolethane, 1,1,1-trimethylolpropane, glycerol, pentaerythritol, sugar alcohols, low molecular alkoxylation products of the said di- and polyhydric alcohols; short-chain polyester polyols like terephthalic acid bis glycol ester; aliphatic, cycloaliphatic and aromatic amine alcohols like ethanolamine, propanolamine, butanolamine, n-methylethanolamine, diethanolamine, triethanolamine; hydrazides of dicarboxylic acids; aliphatic polyamines like ethylenediamine, 1,2- and 1,3-propanediamine, 2-methyl-1,2-propanediamine, 2,2-dimethyl-1,3-propanediamine, 1,3- and 1,4-butanediamine, 1,3- and 1,5-pentanediamine, 1,6-hexamethylenediamine, 2,2,4- and 2,4,4-trimethyl hexamethylenediamine and mixtures thereof,

1,7-heptanediamine, 1,8-octanediamine, 4-aminomethyl-1,8-octanediamine, 1,9-nonanediamine, 1,10-decanediamine, 1,11-undecanediamine, 1,12-dodecanediamine, methylbis(3-aminopropyl)amine, 1,5-diamino-2-methylpentane (MPMB), 1,3-diaminopentane (DAMP), 2,5-dimethyl-1,6-hexamethylenediamine, dimer fatty acid diamines; cycloaliphatic polyamines like 1,2-, 1,3- and 1,4-diaminocyclohexane, bis(4-aminocyclohexyl)-methane, bis(4-amino-3-methylcyclohexyl)methane, bis(4-amino-3-ethylcyclohexyl)methane, bis(4-amino-3,5-dimethylcyclohexyl)methane, 1-amino-3-aminomethyl-3,5,5-trimethylcyclohexane (= isophorondiamine or IPDA, 2- and 4-methyl-1,3-diaminocyclohexane and mixtures thereof, 1,3- and 1,4-bis(aminomethyl)cyclohexane, 1-cyclohexylamino-3-aminopropane, 2,5(2,6)-bis(aminomethyl)bicyclo[2.2.1]heptane (NBDA), produced by Mitsui Chemicals), 3(4),8(9)-bis(aminomethyl)tricyclo[5.2.1.0<sup>2</sup>,6]decane, 1,4-diamino-2,2,6-trimethylcyclohexane (TMCD), 3,9-bis(3-aminopropyl)-2,4,8,10-tetraoxaspiro[5.5]undecane, 1,3- and 1,4-xylylenediamine; ether group-containing aliphatic polyamines like bis(2-aminoethyl) ether, 4,7-dioxadecane-1,10-diamine, 4,9-dioxadodecane-1,12-diamine and higher oligomers thereof; polyoxyalkylenepolyamines with theoretically two or three amino group, which obtainable for example under the trade name Jeffamine® (produced by Huntsman Chemicals); aromatic polyamines like methylenedianiline, diaminophenyl ether, diaminodiphenylsulfone, the isomeric phenylenediamines, aminodiphenylamine are especially suitable for use as hardeners in microencapsulated form. ~~Said~~ The aliphatic, cycloaliphatic and aromatic polyamines are generally preferred. The microencapsulation of these hardeners can be ~~done~~ accomplished by one of the current processes, for example by spray drying, interfacial polymerization coacervation, immersion or centrifuging processes, fluidized bed processes, or vacuum encapsulation, ~~electrostatic~~ Electrostatic microencapsules may generally have a particle size of 0.1 to 100 micrometers, ~~especially and preferably~~ 0.3 to 50 micrometers. The size of the microcapsules is ~~determined~~ preferably large enough to allow the microcapsules to fully so that on the one hand they ~~officially~~ open up on heating and yet small enough to sufficiently distribute the microcapsules throughout the adhesive on the other hand to provide adequate after hardening the adhesive obtains optimum ~~homogeneity and thus cohesive strength after the adhesive hardens. It~~ The microencapsules must preferably not exert cause little if any harmful effect on to the adhesion properties of the adhesive.

Possibilities as material for the capsule shell are polymers that are insoluble in the resin that is to be encapsulated and that have a melting point from 40 to 200°C. Examples of suitable polymers are hydrocarbon waxes, polyethylene waxes, wax esters, polyesters, polyamides, polyacrylates, polymethacrylates of a number of such polymers.

[0030] In a ~~preferred~~one embodiment, both the isocyanate group containing polyurethane polymer and the hardener are ~~present~~provided in blocked form in the polyurethane composition.

[0031] In a second ~~embodiment~~general example, the one-component reactive adhesive is an acrylate composition. Such a composition ~~is characterized by the fact that it contains~~may contain as the resin A ~~that enters into polyreactions~~ at least one divalent or polyvalent monomer that contains an acryl or methacryl group and at least one monomer that contains monofunctional acryl or methacryl group. Examples of suitable di- or polyvalent monomers that contain an acryl or methacryl group are acrylates and methacrylates of aliphatic polyether polyurethanes and polyester polyurethanes, polyethers, polyesters, novolaks, di- and polyvalent aliphatic, cycloaliphatic and aromatic alcohols, glycols and phenols. Examples of monomers that contain a monofunctional acryl or methacryl group are methylacrylate and methacrylate, ethylacrylate and methacrylate, hexylacrylate and methacrylate, dodecylacrylate and methacrylate, tetrahydrofurfuryl acrylate and methacrylate, as well as hydroxyl group-containing acrylates and methacrylates like 2-Hydroxyethyl acrylate and methacrylate and, 2-hydroxypropyl acrylate and methacrylate.

[0032] As hardener B, the acrylate composition ~~contains~~may contain a thermal initiator that initiates the polymerization of the acrylate or methacrylate monomers and that is in blocked form. Examples of suitable thermal initiators ~~are~~include diacyl peroxides like benzoyl peroxide, lauroyl peroxide and decanoyl peroxide; peroxydicarbonates like dipropyl peroxydicarbonate; peroxyoxalates like di-tert-butyl peroxyoxalate; hyponitrites like di-tert-butyl hyponitrite. Benzoyl peroxide is preferred. The blocked thermal initiator, especially benzoyl peroxide, is preferably in microencapsulated form. The preparation of microencapsulated organic peroxides is described in EP 0 730 493 B1, for example.

[0033] In a ~~third~~another embodiment, the one-component reactive adhesive ~~is~~comprises an epoxide composition. Such a composition ~~is characterized by the fact that it contains~~ as the resin A ~~that enters into polyreactions~~ at least one polyepoxide. Examples of suitable polyepoxides are

diglycidyl or polyglycidyl ethers of polyhydric aliphatic, cycloaliphatic or aromatic alcohols, polyalkylene glycols, phenols like bisphenol A or of condensation products of phenol with formaldehyde that are obtained under acid conditions such as phenol novolaks and cresol novolaks; polyglycidyl esters of polyvalent carboxylic acids; and N-glycidyl derivatives of amines, amides and heterocyclic nitrogen bases. Glycidylized novolaks, hydantoins, aminophenols, bisphenols or aromatic diamines are preferred.

[0034] As hardener B, the epoxide composition ~~contains~~ may contain a hardener that contains groups in blocked form that are reactive ~~toward~~ with epoxides ~~and that are in blocked form~~.

Examples of suitable hardeners are amines such as aliphatic, cycloaliphatic, aromatic or araliphatic, preferably primary or secondary, amines and polyamines; adducts and polyalkoxylation products of polyamines; amine-terminated polyalkylene glycols; adducts of monophenols or polyphenols with polyamides; polyamides, especially ones that derive from aliphatic polyamines and dimerized or trimerized fatty acids; polysulfides; aniline-formaldehydes; polyhydric phenols; polyvalent carboxylic acids and their anhydrides. Polyamines and polyaminoamides are preferred hardeners.

[0035] The one-component reactive adhesive additionally generally contains at least one type of nanoparticles "C" with ferromagnetic, ferrimagnetic, superparamagnetic or piezoelectric properties. The term "nanoparticle" in this document designates particles that have crystalline structures and an average particle size or diameter of less than 500 nm, ~~especially preferably~~ less than 200 nm, more preferably less than 50 nm, and especially preferably between 3 and 30 nm. It may be preferable for the particle size to ~~In particular, in order to be able to utilize the properties provided by superparamagnetism, the particle size should not be not much over larger than 30 nm if possible, to maximize the benefits of superparamagnetism.~~ The nanoparticles ~~are~~ may be stimulated by electrical, magnetic and/or electromagnetic alternating fields, so that their surroundings, the matrix of the reactive adhesive, is ~~highly~~ heated locally through transfer of energy. The nanoparticles of piezoelectric substances such as quartz, tourmaline, barium titanate, lithium sulfate, sodium tartrate, potassium tartrate, Seignette salt, ethylenediamine tartrate, lead titanate, lead zirconate, lead-zirconium titanates, lead-zirconium-lanthanum titanates, or ferroelectrics with Perovskite structure are generally suitable for use of electrical alternating fields. Nanoparticles of substances with ferrimagnetic, ferromagnetic or superparamagnetic properties, especially the metals aluminum,

iron, cobalt, nickel and alloys of these metals, and metal oxides of the maghemite ( $\gamma\text{-Fe}_2\text{O}_3$ ), and magnetite ( $\text{FeO}\cdot\text{Fe}_2\text{O}_3$ ) types and especially iron oxide mixtures, the so called ferrites of the general formula  $\text{M}^{\text{II}}\text{O}\cdot\text{Fe}_2\text{O}_3$ , where M stands for one or more metals of the group consisting of manganese, zinc, copper, cobalt, magnesium, calcium or cadmium, are generally suitable for the use of magnetic alternating fields. Such ferrites have Curie temperatures that can be adjusted over a wide range by means of the metal composition. The Curie temperature is the maximum temperature to which a magnetic substance can be heated by the application of a magnetic or electromagnetic alternating field, and it thus corresponds to an intrinsic protection against overheating. Preferably, the Curie temperature lies in the range of 100 to 200°C.

[0036] Superparamagnetic nanoparticles with a narrow particle size distribution from 1 to 15 nm, which are characterized by having no hysteresis or remanence, ~~are~~ may be especially ~~suitable~~ desirable. Such nanoparticles may generally lead to ~~clearly~~ more efficient energy transfer and heating rates by the particles and the adhesive matrix surrounding them.

[0037] In order to guarantee good ~~dispersibility~~ dispersion of the nanoparticles ~~in~~ throughout the adhesive matrix and to prevent agglomeration and coalescence of the nanoparticles during storage of adhesive, the nanoparticles C that are used are preferably surface-modified or coated, or are surrounded by a nonmagnetic, dispersible matrix, preferably pyrogenic oxides of silicon, aluminum, titanium, zirconium or magnesium. The preparation of suitable surface-modified nanoparticles is described in WO 03/54102, for example. The preparation of suitable nanoparticles surrounded by pyrogenic oxides is described EP 1 284 485, for example. The nanoparticles are contained in the reactive adhesive in an amount of 0.1 to 5 wt%, preferably 0.3 to 3 wt%, and especially preferably 0.5 to 2 wt%, ~~with respect to all of~~ as a percentage of the reactive adhesive.

[0038] The one-component reactive adhesive additionally generally contains at least one additive D. For example, the following auxiliary substances and additives are ~~possibilities~~ examples ~~as of~~ suitable additives:

[0039] Plasticizers, for example esters of organic carboxylic acids or their anhydrides, phthalates, for example dioctyl phthalate or diisodecyl phthalate, adipates, for example dioctyl adipate, sebacates, organic phosphoric and sulfonic acid esters, polybutenes and other compounds that do not react with isocyanates; reactive diluents and cross linking agents, for example polyhydric

alcohols, polyamines, polyaldimines, polyketimines or aliphatic isocyanates, for example 1,6-hexamethylene diisocyanate, 2,2,4- and 2,4,4-trimethyl-1,6-hexamethylene diisocyanate, 1,12-dodecamethylene diisocyanate, cyclohexane 1,3- and 1,4-diisocyanate and any mixtures of these isomers, 1-isocyanato-3,3,5-trimethyl-5-isocyanatomethyl-cyclohexane (= isophorone diisocyanate or IPDI), perhydro-2,4'- and -4,4'-diphenylmethane diisocyanate, 1,3- and 1,4-tetramethylxylylene diisocyanate, isocyanurates of these isocyanates, oligomers and polymers of these isocyanates, and their adducts with polyols; inorganic and organic fillers, for example ground or precipitated calcium carbonates, which are optionally coated with stearates, especially finely divided coated calcium carbonate, carbon blacks, kaolins, aluminum oxides, silicic acids and PVC powders or hollow beads; fibers, for example of polyethylene; pigments; catalysts for the reaction of isocyanate group, for example organotin compounds like dibutyltin diacetate, dibutyltin dilaurate, dioctyltin dicarboxylate, dibutyltin dichloride, dibutyltin diacetylacetonate, alkyltin thioesters, organobismuth compounds or bismuth complexes, tertiary amines such as 2,2'-dimorpholinodiethyl ether; polyaldimines, polyketimins or polyoxazolidines; catalysts for the hydrolysis of aldimine, ketimine and oxazolidine group, for example organic carboxylic acids like benzoic acid or salicylic acid, organic carboxylic anhydrides like phthalic anhydride or hexahydrophtalic anhydride, silyl esters of organic carboxylic acids, organic sulfonic acids like p-toluenesulfonic acid or 4-dodecylbenzenesulfonic acid, or other organic or inorganic acids or mixtures of said acids; catalysts for the reaction of the epoxide group such as salicylic acid, dicyanodiamide, tertiary amines or quaternary ammonium compounds, Mannich bases, imidazoles and boron trifluoride or its complexes with organic compounds like ethers and amines, optionally in blocked form; catalysts for acceleration of the acrylate polymerization, for example tertiary amines like N,N-dimethylaniline, N,N-dimethyl-p-toluidine, N,N-dimethylbenzylamine and N-alkylmorpholine, thioureas like 1,3-diethylthiourea, or complexes or salts of nickel, cobalt and copper, and combinations of these catalysts; rheology modifiers such as thickeners or thixotropic agents, for example urea compounds, polyamide waxes, bentonites or pyrogenic silicic acids; auxiliary adhesives, especially silanes like alkylsilanes, epoxyalkylsilanes, vinylsilanes, aldiminoalkylsilanes, methacryloxyalkylsilanes and isocyanatoalkylsilanes, and oligomeric forms; waxes; drying agents, for example p-tosyl isocyanate and other reactive isocyanates, orthoformic

acid esters, calcium oxide or molecular sieves; stabilizers to protect against heat, light and UV radiation; flame retardants; surface-active substances, for example wetting agents, flow aids, deairing agents or antifoaming agents; fungicides or mold inhibitors; as well as other substances that are usually used in reactive adhesives. One of skill in the art will generally recognize ~~It is clear to the specialist~~ which auxiliary substances and additives are suitable for the relevant ~~form of use of the~~ reactive adhesive.

[0040] ~~Such~~ The one-component adhesives are generally simple to use. Because of the blocking of the resin A and/or hardener B they are extremely ~~storage-stable during storage~~. ~~In the preferred embodiments~~ Additionally, they are generally not ~~susceptible~~ affected ~~to by~~ moisture because of the blocking of resin A and/or hardener B. They harden rapidly under the effect of electrical, magnetic and/or electromagnetic alternating fields. They have good mechanical strength, and these properties ~~can~~ may generally be adjusted ~~over a wide range~~ for a wide variety of applications.

#### EXAMPLES OF REACTIVE ADHESIVES: TWO-COMPONENT SYSTEMS

[0041] In the case of two-component ~~systems~~ reactive adhesives, one component ~~must be~~ is generally kept separate from the other component and ~~be~~ released in a controlled ~~way~~ manner to mix the two components together ~~in the application~~. The reactive adhesive thus ~~consists~~ generally comprises of a resin and a hardener, where both components are separated by a membrane. This membrane ~~must be destroyed~~ may generally be pierced or ruptured to allow the resin and hardener to mix ~~in the application~~, preferably by mechanical means. Various methods can be used to separate the two components ~~by membrane~~, such as, for example:

- a) microencapsulation of one component,
- b) adsorption of each component separately in a foam or nonwoven material, and optionally separating them by membrane, or
- c) enclosing each component in a container of thin plastic film.

[0042] Figure 3 shows a fastening element in accordance with ~~the invention~~ one embodiment that additionally has rupturing element 7, in this case sharp points. If one of the components ~~are kept~~ is confined within containers 8 as shown in Figure 4, especially containers of a thin film, or in absorbent materials like nonwovens that are optionally separated by membrane 10, as shown in



Figure 5, these components can be released by application of the rupturing means such as rupturing element 7. This is shown here as mechanical rupture by the sharp points, which punch holes in the membranes upon use. One of skill in the art will generally recognize that many other embodiments of rupturing element 7 are possible. For the sake of brevity, each possible embodiment is not specifically described herein~~However, the release of the components can also take place by any other means.~~

**[0043]** A viscosity < 7000 mPa·sec is ~~necessary~~ generally preferable for thorough mixing of the components. The viscosity can be ~~set~~ adjusted by ~~an increase~~ increasing ~~of the~~ temperature. This increase of temperature can take place by introduction of microwaves or by induction, and the absorption of energy can be improved by absorbent particles in the adhesive formulation such as electrically conductive particles or nano- or microscale ferrites, as ~~was also described above in the examples for the one-component systems.~~

**[0044]** Examples of the ~~The storage-stable reactive adhesives that are in the form of separated components can be based, for example on~~ include:

#### 1) Epoxide Resins and Hardeners

**[0045]** Any epoxide resins can be used here as the epoxide resin; preferably, the epoxide resin contains at least two epoxide groups in the molecule. Suitable epoxide resins are especially those with more than one epoxide group,  $\beta$ -methylglycidyl group or 2,3-epoxycyclopentyl group that are bonded to a heteroatom, for example sulfur, but preferably oxygen or nitrogen, especially bis(2,3-epoxycyclopentyl) ether, diglycidyl or polyglycidyl ethers of polyhydric aliphatic or aromatic alcohols like 1,4-butanediol, or polyalkylene glycols like polypropylene glycol; diglycidyl or polyglycidyl ethers of cycloaliphatic polyols like 2,2-bis(4-hydroxycyclohexyl)propane; diglycidyl or polyglycidyl ethers of polyhydric phenols like resorcinol, bis(p-hydroxyphenyl)methane, 2,2-bis(p-hydroxyphenyl)propane (bisphenol-A), 2,2-bis(4'-hydroxy-3',5'-dibromophenyl)propane and 1,1,2,2-tetrakis(p-hydroxyphenyl)ethane, or of condensation products of phenols with formaldehydes, that are obtained under acid conditions such as phenol novolaks and cresol novolaks and the di( $\beta$ -methylglycidyl) or poly( $\beta$ -methylglycidyl) ethers of said polyhydric alcohols or phenols. In addition, polyglycidyl esters of polyvalent

carboxylic acids like phthalic acid, terephthalic acid, tetrahydrophthalic acid and hexahydrophthalic acid, the N-glycidyl derivatives of amines, amides and heterocyclic nitrogen bases like N,N-diglycidylaniline, N,N-diglycidyltoluidine, N,N,O-triglycidyl-p-aminophenol, N,N,N',N'-tetraglycidyl-bis(p-aminophenyl)methane and triglycidyl isocyanurate.

[0046] Glycidylized novolaks, hydantoins, aminophenols, bisphenols or aromatic diamines are a preferred group of the epoxide resins. As resin, preferred compositions also contain a glycidylized cresol novolak, bisphenol-A diglycidyl ether or a bisphenol-A diglycidyl ether that has been lengthened, for example with bisphenol-A, dimer fatty acids or a mixture thereof, and their mixtures with aliphatic diglycidyl ethers.

[0047] Possible epoxide hardeners ~~are~~ may include acid or base compounds. Examples of suitable hardeners are amines like aliphatic, cycloaliphatic, aromatic or araliphatic, preferably primary or secondary amines such as ethylenediamine, hexamethylenediamine, trimethylhexamethylenediamine, diethylenetriamine, triethylenetetramine, tetraethylenepentamine, N,N-dimethylpropylene-1,3-diamine, N,N-diethylpropylene-1,3-diamine, 2,2-bis(4'-aminocyclohexyl)propane, 3,5,5-trimethyl-3-(aminomethyl)cyclohexylamine (isophoronediamine), m-phenylenediamine, p-phenylenediamine, bis(4-aminophenyl)methane, bis(4-aminophenyl)sulfon and m-xylylenediamine; adducts of polyalkylenepolyamines, for example diethylenetriamine or triethylenetetramine, with acrylonitrile or monoepoxides such as ethylene oxide or propylene oxide; amine-terminated polyalkylene glycols, for example those obtainable under the name Jeffamine® (Huntsman); adducts of polyamines, like diethylenetriamine or triethylenetetramine, with polyepoxides, like bisphenol-A diglycidyl ether, prepared with an excess of said polyamines; adducts of monophenols or polyphenols with polyamides; polyamides, especially those that derive from aliphatic polyamines such as diethylenetriamine or triethylenetetramine, and dimerized or trimerized fatty acids (for example, Versamide®, of dimerized linoleic acid); polysulfides, for example those obtainable under the name Thiokol® aniline formaldehydes; polyhydric phenols, for example resorcinol, 2,2-bis(4-hydroxyphenyl)propane or phenolformaldehyde resins (novolaks); polyvalent carboxylic acid and their anhydrides, for example phthalic anhydride, tetrahydrophthalic anhydride, hexahydrophthalic anhydride, 4-methylhexahydrophthalic anhydride,

3,6-endomethylenetetrahydrophthalic anhydride, 4-methyl-3,6-endomethylene-4-tetrahydrophthalic anhydride (methylnadic anhydride), succinic anhydride, adipic anhydride, trimethyladipic anhydride, sebacic anhydride, maleic anhydride, dodecylsuccinic anhydride, pyromellitic anhydride, trimellitic anhydride, benzophenonetetracarboxylic dianhydride, or mixtures of anhydrides. Amines and polyaminoamides ~~are~~ may be preferred-preferable as hardeners.

[0048] The composition can also contain accelerators or hardening catalysts. Examples are: tertiary amines or quaternary ammonium compounds, Mannich bases like 2,4,6-tris(dimethylaminomethyl)phenol, benzyldimethylamine, 2-ethyl-4-methylimidazole, monophenols or polyphenols like phenol and bisphenol-A, salicylic acid, dicyanodiamide, boron trifluoride and its complexes with organic compounds like ethers and amines, for example  $\text{BF}_3$ -monoethylamine and  $\text{BF}_3$ -acetoacetanilide, phosphoric acid and triphenylphosphine. Tertiary amines, Mannich bases and imidazoles ~~are~~ may generally be preferred.

[0049] In addition, the resin can contain various agents which improve ductility-improvers, such as carboxyl-terminated polybutadienes or core-shell particles, as well as thixotropic agents, for example ones based on a urea derivative in a nondiffusing carrier material. Advantageously, this thixotropic agent contains a blocked polyurethane prepolymer as carrier material. The preparation of such urea derivatives and carrier materials are described in detail in EP 1 152 019 A1.

## 2) Polyisocyanates and Polyol or Polyamine Hardeners

[0050] Suitable systems ~~are~~ may include, for example:

- Polyoxyalkylene polyols, also called polyether polyols, which are the polymerization products of ethylene oxide, 1,2-propylene oxide, 1,2- or 2,3-butylene oxide, tetrahydrofuran and mixtures thereof, optionally polymerized with the help of a starter molecule that has two or three active H atoms such as water or compounds with two or three OH groups. Both polyoxyalkylene polyols that have a low degree of unsaturation (measured in accordance with ASTM D-2849-69 and given in milliequivalents of unsaturation per gram of polyol (meq/g)), prepared, for example, with the help of the so called Double Metal Cyanide Complex Catalysts (DMC Catalysts), and also polyoxyalkylene polyols with a higher degree of unsaturation, which are prepared for example with the help of anionic catalysts like

NaOH, KOH or alkali alcoholates, can be used. Polyoxypropylenediols and -triols with degree of unsaturation below 0.02 meq/g and molecular weight from 1000 to 30,000 g/mol, polyoxybutylenediols and triols, polyoxypropylenediols and triols with molecular weight from 400 to 8000 g/mol, as well as the so call "EO-end capped" (ethylene oxide-end capped) polyoxypropylenediols or -triols are particularly suitable. The latter are particular polyoxypropylene polyoxyethylene polyols, which can be obtained, for example, by alkoxylating pure polyoxypropylene polyols after completion of the polypropoxylation with ethylene oxide and which because of that have primary hydroxyl groups.

- Polyhydroxy-terminated polybutadiene polyols, such as those prepared by polymerization of 1,3-butadiene and allyl alcohol;
- Styrene-acrylonitrile grafted polyether polyols, for instance those sold by Bayer under the name Lupranol;
- Polyhydroxy-terminated acrylonitrile/polybutadiene copolymers, as can be prepared, for example, for carboxyl-terminated acrylonitrile/polybutadiene copolymers (commercially obtainable under the name Hycar® CTBN Hanse Chemie) and epoxides or from amino alcohols;
- Polyester polyols, prepared, for example, from dihydric to trihydric alcohols such as 1,2-ethanediol, diethylene glycol, 1,2-propanediol, dipropylene glycol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, neopentyl glycol, glycerol, 1,1,1-trimethylolpropane or mixtures of said alcohols with organic dicarboxylic acids or their anhydrides or esters such as succinic acid, glutaric acid, adipic acid, suberic acid, sebacic acid, dodecanedicarboxylic acid, maleic acid, fumaric acid, phthalic acid, isophthalic acid, terephthalic acid, and hexahydrophthalic acid or mixtures of said acids, as well as polyester polyols from lactones such as  $\epsilon$ -caprolactone;
- Polycarbonate polyols, such as are obtainable by the reaction of, for example, said alcohols (those used for synthesis of the polyester polyols) with dialkyl carbonates, diaryl carbonates or phosgene.

[0051] Advantageously, the isocyanate-reactive polymers are difunctional or more highly functional polyols with OH equivalent weights from 600 to 6000 g/OH-equivalent, especially from

600 to 4000 g/OH-equivalent, preferably 700 to 2200 g/OH-equivalent. Moreover, the polyols ~~are~~ may be advantageously chosen from the group consisting of polyethylene glycols, polypropylene glycols, polyethylene glycol polypropylene glycol block copolymers, polybutylene glycols, hydroxyl-terminated polybutadienes, hydroxyl-terminated polybutadiene-coacrylonitriles, hydroxyl-terminated synthetic rubbers and mixtures of the said polyols.

[0052] Moreover, difunctional or more highly functional amine-terminated polyethylene ethers, polypropylene ethers, polybutylene ethers, polybutadienes, polybutadiene/acrylonitriles (for example, Hycar® CTBN from Hanse Chemie), and other amine-terminated synthetic rubbers or mixtures of the said components can be used as isocyanate-reactive polymers.

[0053] It is further possible for the isocyanate-reactive polymers to also be chain-lengthened, such as can be prepared from the reaction of polyamines, polyol and polyisocyanates, especially diamines, diols and diisocyanates, as is generally known in the art~~in the way that is well known to the specialist.~~

[0054] Polyols with molecular weights between 600 and 6000 g/mol, chosen from the group consisting of polyethylene glycols, polypropylene glycols, polyethylene glycol-polypropylene glycol block copolymers, polybutylene glycols, hydroxyl-terminated polybutadienes, hydroxyl-terminated polybutadiene-acrylonitrile copolymer and their mixtures ~~are~~ may generally be preferred ~~preferable~~ as isocyanate-reactive polymers.

[0055] ~~Especially preferred as isocyanate-reactive polymers are~~ such as  $\alpha,\omega$ -polyalkylene glycols with C<sub>2</sub>-C<sub>6</sub> alkylene groups or with mixed C<sub>2</sub>-C<sub>6</sub> alkylene groups that are terminated with amino, thiol or, preferably hydroxyl groups may be especially preferable. Polypropylene glycol and polybutylene glycol ~~are~~ may also be especially preferred.

[0056] Diisocyanates, triisocyanates or tetraisocyanates, especially di- or triisocyanates, are generally suitable as polyisocyanates. Diisocyanates are preferred. Aliphatic, cycloaliphatic, aromatic or araliphatic diisocyanates are suitable as diisocyanates, especially the commercial products like methylenediphenyl diisocyanate (MDI), hexamethylene diisocyanate (HDI), toluene diisocyanate (TDI), tolidine diisocyanate (TODI), isophorone diisocyanate (IPDI), trimethylhexamethylene diisocyanate (TMDI), 2,5- or 2,6-bis(isocyanatomethyl)bicyclo[2.2.1]heptane, 1,5-naphthalene diisocyanate (NDI),

dicyclohexylmethyl diisocyanate(H<sub>12</sub>MDI), p-phenylene diisocyanate (PPDI), m-tetramethylxylylene diisocyanate (TMXDI), and their dimers. HDI, IPDI, TMDI, MDI and TDI are preferred.

**[0057]** Suitable triisocyanates are in particular trimers or biurets of aliphatic, cycloaliphatic, aromatic or araliphatic diisocyanates, especially the isocyanurates and biurets of the diisocyanates described in the previous paragraph.

**[0058]** Additionally suitable are particles of solid polyisocyanates that have been deactivated at the surface, as are described in R. Blum and H. Schupp, Progress in Organic Coatings (1990) pp. 275-288.

### 3) Acrylates and Methacrylates and Microencapsulated Radical Initiators

**[0059]** ~~Suitable~~ Examples of these systems are described, for example, in the application WO 02/070620 A1 and the literature indicated therein. They ~~consist of~~ may comprise methacrylic acid esters like methyl methacrylate and tetrahydrofurfuryl methacrylate as well as aliphatic polyurethane acrylates, elastomers reacted with acrylic acid such as polybutadiene-acrylonitrile-copolymers (trade name Hycar® VTBNX) or core-shell polymers. Other suitable systems, which essentially consist of mixtures of methacrylates with elastomers, are described US 3,890,407, US 4,106,971 and US 4,263,419, for example. Possibilities as initiators are in particular organic peroxides, especially benzoyl peroxide in combination with catalysts like tertiary amines and/or complexes or salts of transitions metals. Examples of tertiary amines are N,N-dimethylbenzylamine and N-alkylmorpholine. Examples of complexes or salts of transitions metals are complexes or salts of nickel, cobalt and copper.

**[0060]** The preparation of microencapsulated radical initiators like peroxides is described, for example in EP 0 730 493 B1.

### USE OF THE FASTENING ELEMENTS:

**[0061]** ~~According to~~ As shown in Figure 1, the fastening elements 1 are ~~may be~~ placed in a fastening device 2. The fastening element 1 ~~is~~ may then be pressed against or otherwise applied to ~~the base element 5 with fastening element 2. Base element 5 may be, for example, a construction~~

surface of glass, steel, concrete, etc., ~~by means of the fastening device~~. The fastening device ~~is~~ may be designed so that the adhesive can be heated. The way the heating takes place is dependent on the adhesive system and ~~can take place~~ may be accomplished, for example, by induction, thermal radiation, etc. In the case of the two-component systems described above with components separated by membranes 8 and 10 (see Figures 4 and 5) said components are generally released with the rupturing elements 7 when the fastening element 1 is pressed against ~~the~~ base element 5. The reactive adhesive 4 ~~is now~~ may then be heated through with, for example, ~~the~~ fastening device 2, which leads to rapid hardening. This heating ~~is~~ may advantageously done be carried out by means of alternating fields, such as in ~~like~~ conduction or use of microwaves. Particles with ferromagnetic, ferrimagnetic, superparamagnetic or piezoelectric properties ~~are~~ may be arranged in the reactive adhesive 4 as described above and ~~are~~ can be heated by the radiation. Advantageously, these particles ~~are~~ may be nanoparticles. Rapid hardening ~~is possible~~ may therefore occur through as a result of the radiation-induced heating of the adhesive, without the surroundings besides reactive adhesive 4 also being significantly heated.

[0062] If rapid hardening is not possible because of the type of reactive adhesive 4 that is chosen, a temporary adhesion to ~~the~~ base element 5 can be produced by means of auxiliary adhesives 6 arranged on ~~the~~ fastening element 1. As such, auxiliary adhesive 6 may maintain fastener element 1 to base element 5 while reactive adhesive 4 is hardening, preferably at least until reactive adhesive 4 has hardened sufficiently to bond fastening element 1 to base element 5 the adhesion is taken on by the [primary] adhesive.

[0063] After sufficient adhesion has formed between ~~the~~ fastening element 1 and ~~the~~ base element 5, ~~the~~ fastening device 2 can be removed from ~~the~~ fastening element 1. After hardening is complete or when sufficient force has developed, other elements can be placed on ~~the~~ fastening element 1. In the construction field these can be, for example, roof elements, glazings, insulations, conduits, and so forth. The reactive adhesive 4 of the fastening element 1 can additionally also be covered by a cover that is removed before processing. The cover may generally provide added protection for reactive adhesive 4 from the external environment. Use of a cover may be ~~This is~~ especially advantageous when the fastening element has auxiliary adhesives.

[0064] According to Figure 6 a primer layer or auxiliary adhesive layer 11 can additionally be applied to the fastening element 1. Such a primer or auxiliary adhesive layer 11 can be situated between the fastening element 1 and the adhesive 4 and/or on the adhesive as shown. ~~Perhaps another~~ Additionally, other protective mechanisms ~~will have to~~ may be arranged ~~employed~~ between the adhesive layer and the primer or auxiliary adhesive layer, so that ~~these~~ the various layers do not react with each other prematurely.

[0065] In order to protect layer ~~12~~ 11 until the fastening element 1 is ~~used~~ installed, a protective layer 12 ~~is advantageously~~ may be arranged on layer 11. It ~~can~~ may generally be removed before the use of the fastening element 1, or it can be used in a manner analogously to the rupturing element 7 shown in Figure 3.

[0066] Primers based on isocyanates, epoxides, acrylates or silanes ~~are~~ may be especially ~~suitable~~ desirable as primers. Primers based on epoxide resins are especially well suited for porous substrates. Typically, such primers contain solvents, especially aromatic solvents like xylene, toluene or White spirit, or ketones like methyl ethyl ketone, or alcohols like methanol or ethanol or isopropanol. One of skill in the art will generally recognize ~~It is clear to the specialist that the solvent is chosen~~ may be selected so that it does not react with the functional groups present in the primary in each case, i.e., isocyanates, epoxide or silane. In addition, primers can typically contain fillers, especially carbon black.

[0067] Compositions that contain silanes, titanates and/or zirconates ~~are especially suitable~~ may be desirable as adhesion aids. Such silanes, titanates and/or zirconates are characterized by the fact that they have at least one functional group that is bonded to a silicon, titanium or zirconium atom. In addition, such silanes, titanates and/or zirconates preferably have at least one organic substituent that is bonded via a carbon-silicon or carbon-titanium or carbon-zirconium bond to the silicon, titanium or zirconium atom. Alkoxysilanes, especially trialkoxysilanes that, have at least one, preferably one organic substituent are especially preferred. Adhesion aid compositions additionally preferably contain a solvent that has a boiling point that is preferably lower than 100°C. Preferred solvents are alcohols, especially isopropanol.



[0068] Instead of the mechanical rupturing elements to rupture the membrane or other (protective) layers it is also possible to use thermal methods, in which ferrites, for example, are incorporated into the membranes or layers that are to be ruptured. These ferrites can be stimulated by the appropriate electromagnetic fields, ~~and are thereby heated~~ heating the ferrites and thus ~~destroy~~ piercing or rupturing the membrane. The membranes or layers can also be adjusted by means of their melting point so that they readily melt and thus are easily ~~destroyed~~ ruptured without the use of ferrites.

~~Of course, the invention is not limited to the indicated and described embodiment examples.~~

## CONCLUSION

[0069] Fastening element 1 thus provides a simple and reliable attachment feature for construction and other rigorous applications. The fastening element may be applied to virtually any substrate, since the reactive adhesive can easily be matched to various substrate materials. Additionally, the particles arranged in the adhesive may enable even more rapid hardening of the adhesive by reacting to application of alternating fields. One-component adhesives with blocking may provide an extremely simple adhesive that is very stable during storage, and generally not susceptible to moisture. Two-component adhesives may generally provide similar benefits, although the two components are preferably separated to prevent reaction prior to application of the fastening element. Either one-component or two-component adhesives allow for rapid hardening by radiation-induced heating of the adhesive without affecting the surroundings of the fastening element. Finally, both types of adhesives allow for robust mechanical strength for a variety of materials and applications.

[0070] With regard to the processes, systems, methods, etc. described herein, it should be understood that, although the steps of such processes, etc. have been described as occurring according to a certain ordered sequence, such processes could be practiced with the described steps performed in an order other than the order described herein. It further should be understood that certain steps could be performed simultaneously, that other steps could be added, or that certain steps described herein could be omitted. In other words, the descriptions of processes herein are

provided for the purpose of illustrating certain embodiments, and should in no way be construed so as to limit the claimed invention.

[0071] Accordingly, it is to be understood that the above description is intended to be illustrative and not restrictive. Many embodiments and applications other than the examples provided would be apparent to those of skill in the art upon reading the above description. The scope of the invention should be determined, not with reference to the above description, but should instead be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. It is anticipated and intended that future developments will occur in the arts discussed herein, and that the disclosed systems and methods will be incorporated into such future embodiments. In sum, it should be understood that the invention is capable of modification and variation and is limited only by the following claims.

[0072] All terms used in the claims are intended to be given their broadest reasonable constructions and their ordinary meanings as understood by those skilled in the art unless an explicit indication to the contrary is made herein. In particular, use of the singular articles such as "a," "the," "said," etc. should be read to recite one or more of the indicated elements unless a claim recites an explicit limitation to the contrary.